Computing paths to asteroids helps find future exploration opportunities

July 3 2014, by Bill Steigerwald

This image of asteroid 433 Eros is a mosaic of images from NASA's Near Earth Asteroid Rendezvous (NEAR-Shoemaker) spacecraft, which visited the asteroid in 2000. The images were combined with elevation data from the spacecraft's laser rangefinder to build a 3D representation of the asteroid. Credit: Credit: NEAR Project, NLR, JHUAPL, Goddard SVS, NASA

(Phys.org) —As left over building blocks of the solar system's formation, asteroids are of significant interest to scientists. Resources, especially water, embedded within asteroids could be of use to astronauts traveling through deep space. Likewise, asteroids could continue to be destinations for robotic and human missions as NASA pioneers deeper into the solar system, to Mars and beyond.

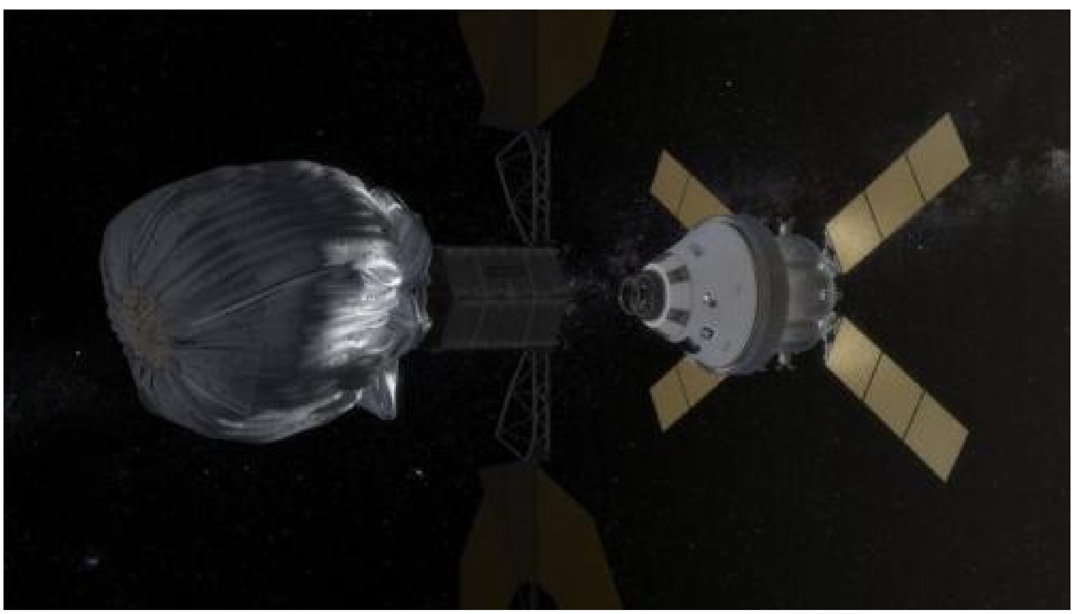
NASA is developing the capabilities needed for astronauts to reach Mars in the 2030s.

To test these new technologies, the agency is planning a mission to identify, capture and redirect an asteroid to a stable orbit around the moon in the 2020s, which astronauts will visit. NASA is studying candidate asteroids for the Asteroid Redirect Mission (ARM). One of the systems that helps to identify such an asteroid is the Near-Earth Object Human Space Flight Accessible Targets Study (NHATS) developed and maintained at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

NHATS is an automated system that uses specialized computer algorithms to compute spacecraft trajectories for possible round-trip mission opportunities to visit a Near-Earth Asteroid (NEA). It is the first study to perform a thorough investigation of NEA accessibility for human space flight and the only automated accessibility monitoring system of its kind in the world. After two years of operation, NHATS has identified more than 1,000 NEAs that could be destinations for future robotic or human missions, enabled by future technology. In the near-term, some of them could be potential candidates for the ARM mission.

"We didn't know what the NEA-accessibility landscape for human spaceflight really looked like until the NHATS was created," said Brent Barbee of NASA Goddard, NHATS project lead. "As of 1 July, 2014, there are now 1,217 NEAs identified by our project that require less flight time and energy to visit and return from than does a Mars mission."

Asteroids have a wide range of sizes, from about the size of a car to objects resembling small moons hundreds of miles across. Their gravity is relatively weak, making them interesting targets for exploration missions. Most asteroids are found in the Main Asteroid Belt between the orbits of Mars and Jupiter, but there is a substantial population whose orbits come close to Earth's. Small asteroids are much more numerous than big ones – astronomers estimate near-Earth space likely contains millions of NEAs a few yards (meters) across, nearly 16,000 NEAs between 100 and 300 yards across, and nearly 5,000 NEAs between 300 and 1,000 yards in size. To be classified as a NEA, the asteroid's orbit must come within 1.3 times the average distance of Earth's orbit about the Sun.



This conceptual image shows NASA's Orion spacecraft (right) approaching the robotic asteroid capture vehicle, which has an asteroid in its capture bag (left). Credit: NASA

Because their orbits take them close to Earth's orbit, some NEAs are potential Earth impact threats. NASA has a program to detect NEAs, estimate their orbits, and assess whether they pose an impact risk. The automated Sentry system identifies potentially hazardous Near-Earth Objects (NEOs – "objects" includes comets as well as asteroids) using observations from telescopes at observatories around the world and in space. Sentry was designed and implemented, and is managed, by NASA's NEO Program Office at the Jet Propulsion Laboratory (JPL) in Pasadena, California.

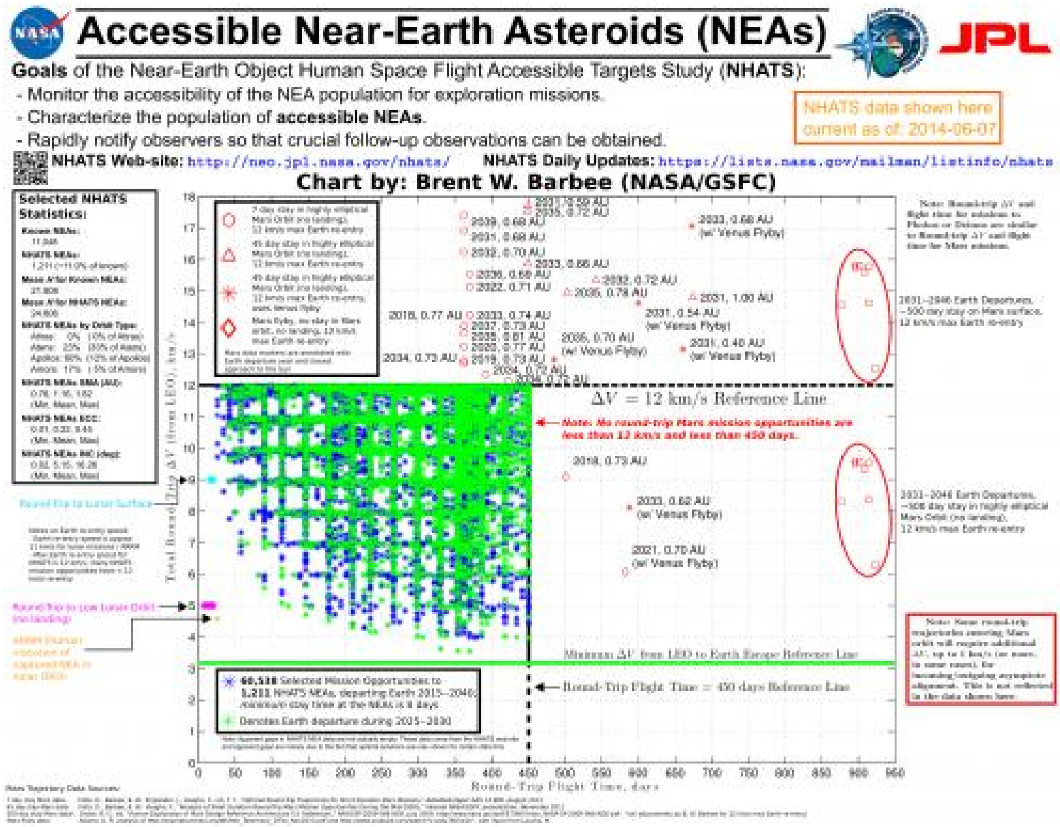
All telescopic observations of NEOs (professional and amateur) to determine their position and orbit are transmitted to the Minor Planet Center (MPC), which is the International Astronomical Union (IAU) sanctioned global clearinghouse for all such observational data. Once an initial orbit is determined, the MPC delivers the observational data for NEOs to JPL, which then computes a higher precision orbit for the NEOs based on the observational data. The orbit data for each NEO can be accessed through JPL's Small-Body Database , and the JPL Horizons system provides an interface through which ephemeris data (position and velocity versus time) can be accessed for each of the NEOs.

Barbee developed the NHATS system to find easily accessible asteroid mission opportunities based on the JPL/Horizons data. "In a sense, the NHATS system complements hazard tracking," said Barbee. "The NHATS system monitors the opportunities offered by NEAs, while the JPL Sentry system monitors the hazards NEAs may pose to Earth."

Each day the NHATS system downloads the list of the known NEAs, figures out which ones are newly discovered and which ones have updated orbit data available, and then downloads the orbit data files for those NEAs from Horizons. The NHATS system then applies the NHATS algorithms to each of those NEA orbit data files to compute all the possible round-trip trajectories to those NEAs using a method of embedded trajectory grids that Barbee developed. Embedded trajectory grids are used to calculate the various possible spacecraft paths, or trajectories, to a target NEA based on mission criteria.

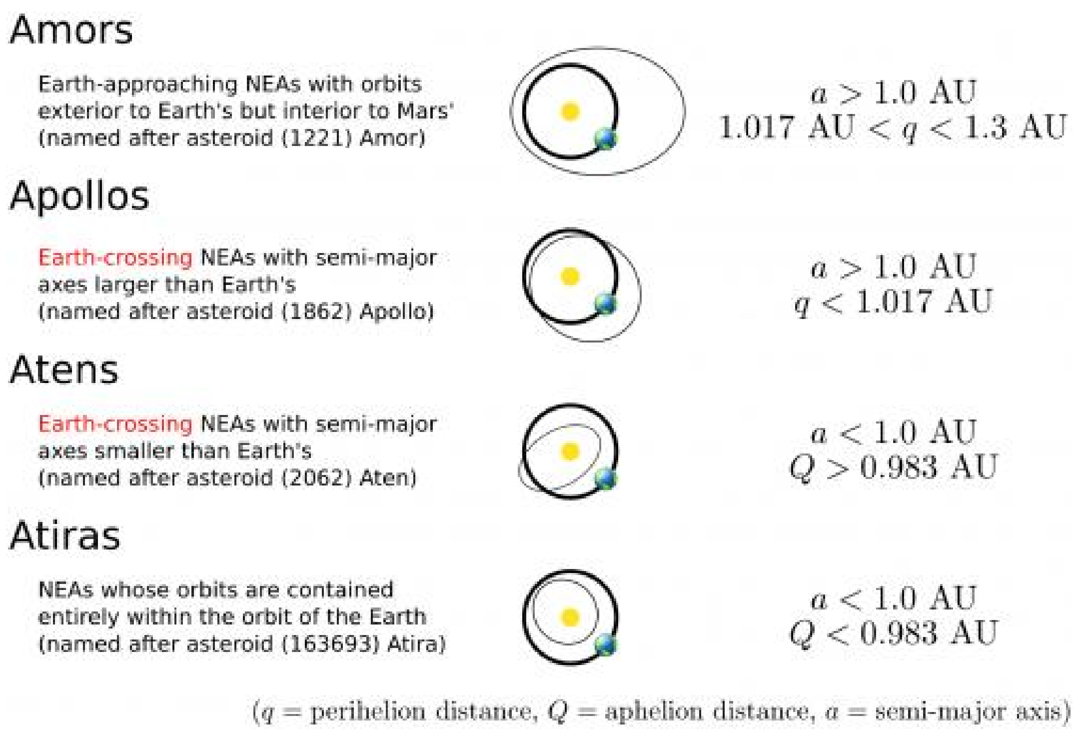
In order for a NEA to be identified as a potential human mission destination, it must meet several criteria. "The NHATS criteria were developed by a human exploration committee in September of 2010," said Barbee. "The idea was for the criteria to mean that round-trip missions to the NHATS-compliant NEAs would be less demanding than even the least demanding round-trip missions to Mars." The criteria include departure dates not too far in the future (no later than 2040), a reasonable amount of time at the asteroid to explore (at least 8 days), a round-trip flight time of 450 days or less, and a lower fuel requirement than a Mars mission.

Barbee maintains a mailing list to which the GSFC NHATS computer automatically transmits each day's processing results.



This chart shows the human-crewed mission opportunities to NEAs that have been identified as of June 7, 2014. Blue and green asterisks are missions that require less time (horizontal axis) and energy (vertical axis) than a Mars mission. This chart is updated every few months. Credit: Brent Barbee

"Anyone can sign up for the mailing list, but the intent is for astronomers and NEO scientists to sign up so that they receive rapid notification when a NEA is discovered that is particularly accessible. This helps ensure that follow-up observations are obtained in a timely manner," said Barbee.

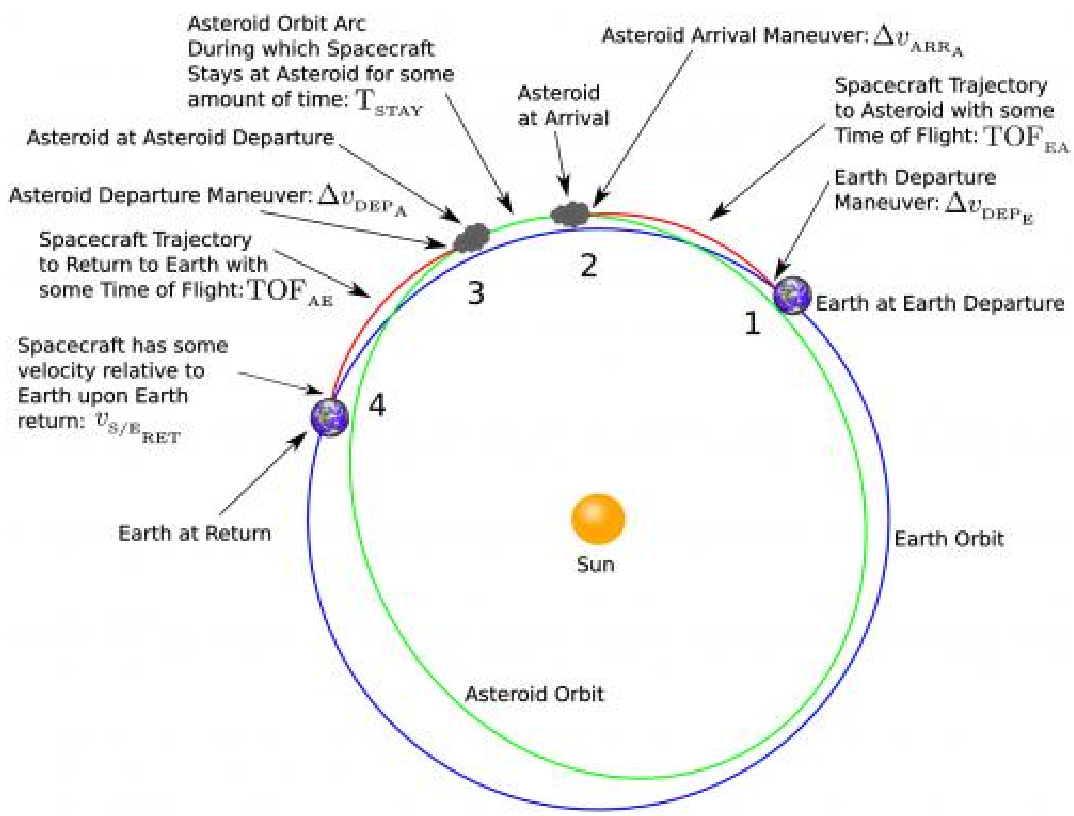


This diagram shows various NEA orbits. The yellow dot is the Sun, the blue-green dot is Earth, and the thick black line is Earth's orbit. The thin black line is the NEA's orbit. AU is Astronomical Unit, Earth's approximate distance from the Sun, about 93 million miles (almost 150 million km). Credit: Brent Barbee

"I check the daily NHATS results message as soon as it arrives to see what 'the night's catch' brought in for newly discovered and updated NEAs," said Lindley Johnson, NASA's NEO Programs Executive. "The information is crucial because it's our first look at opportunities to observe smaller NEAs when they are very close to Earth. Most often we have only a few days after discovery to make follow-up observations, so rapid notification is critical. Follow-up observations are important because they allow us to establish the NEA's orbit around the Sun more accurately, and to learn about the NEO's spin state, size, and composition. All of that information is vital for mission planning."

NHATS began in September of 2010 but was not fully automated until

March 20, 2012. Barbee expects the project to continue indefinitely, as there are many more mission opportunities to be found. "At present we have discovered 11,180 NEOs of all sizes, and we estimate that there are at least 10,000 NEOs larger than 100 yards in size that we haven't found yet," said Barbee. Many will also provide opportunities for longer-duration robotic spacecraft missions.



This diagram illustrates the parts of a conceptual human-crewed mission to an asteroid. The blue oval represents Earth's orbit, the green oval is the asteroid's orbit, and the red arcs are the spacecraft's trajectory to and from the asteroid. Credit: Brent Barbee

An example of a long-duration robotic asteroid sample return mission is the Origins Spectral Interpretation Resource Identification

Security—Regolith Explorer (OSIRIS-REx) mission managed by NASA's Goddard Space Flight Center, which will investigate and return a sample from a NEA named Bennu. Scheduled for launch in late 2016, the spacecraft will reach Bennu in 2018 and return a sample to Earth in 2023.

NASA's asteroid initiative is underway to support the agency's efforts to understand the population of potentially hazardous NEOs and characterize a subset of interest, including those suitable for future asteroid exploration missions. The initiative brings together the best of NASA's science, technology and human exploration efforts to achieve President Obama's goal of sending humans to an asteroid by 2025.

Provided by NASA

Citation: Computing paths to asteroids helps find future exploration opportunities (2014, July 3) retrieved 20 April 2024 from https://phys.org/news/2014-07-paths-asteroids-future-exploration-opportunities.html